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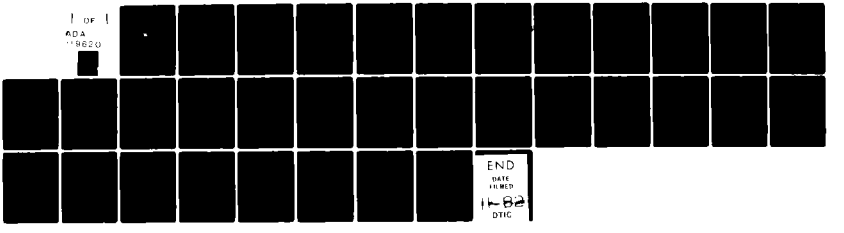

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# TRANSLATION OF FUNCTIONAL TASKS OF A NAVAL WORKSTATION TO STRUCTURED JOB ELEMENTS

RICHARD H. SHANNON


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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>NBDL-82R007 | 2. GOVT ACCESSION NO.<br>AD-A119 620 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE *(and Subtitle)*<br>Translation of Functional Tasks of a Naval Workstation to Structured Job Elements | | 5. TYPE OF REPORT & PERIOD COVERED<br>Research Report<br>6. PERFORMING ORG. REPORT NUMBER<br>NBDL-82R007 |
| 7. AUTHOR(s)<br>Richard H. Shannon | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Naval Biodynamics Labaoratory<br>Box 29407<br>New Orleans, Louisiana 70189 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>MF58.524-02E-0002 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>National Medical Research & Development Command<br>National Naval Medical Center<br>Bethesda, MD 20014 | | 12. REPORT DATE<br>March 1982<br>13. NUMBER OF PAGES |
| 14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)* | | 15. SECURITY CLASS. *(of this report)*<br>Unclassified<br>15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Job analysis, PAQ Generic Workstation

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Two task inventories, Combat Information Control Officer (CICO) in the E2 aircraft and the Operations Specialist Rating (OS) containing respectively 249 and 325 tasks, were translated into structured job elements of the Position Analysis Questionnaire (PAQ). Both of these rating profiles represented functions performed in Naval Combat Information Centers by 35 (CICO) and 1909 (CICO) people. The adequacy of the translation was determined through a correlational comparison with other PAQ profiles from similar jobs. Seven sets of Radarman Rating (RD) scores were provided by PAQ Services from their

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computer files. The average correlation between CICO/RD and OS/RD were, respectively, .477 and .546, which compared rather well with the average correlation of .528 among the seven RD scores. When these ratings were pooled, the reliability coefficient using the Spearman-Brown formula was .913. The attribute requirements of these ratings were then isolated and these indicated that cognitive skills, visual perception/interpretation, and quantitative skills were critical to performance within the tactical command and control workstation.

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## SUMMARY PAGE

### PROBLEM

Many task inventories are now in existence which outline specific duties performed by numerous people within a particular job. The problem is to translate this information into a structured job questionnaire, which then can assist in the specification of critical attributes of that job. This information then forms the basis for recommended batteries of tests that can evaluate performance on that job. This paper examines the Combat Information Control Officer (CICO) and the Operations Specialist (OS) Rating task inventories which include information, respectively, pertaining to 35 and 1909 people. The duties performed in these two inventories were translated into structured job elements using the Position Analysis Questionnaire (PAQ). Both of these rating profiles represented functions performed in Naval Combat Information Centers. The adequacy of the translation was determined through correlational comparison with other PAQ profiles from similar jobs. Seven sets of Radarman Rating (RD) scores were provided by PAQ Services from their computer files.

### FINDINGS

The average correlations between CICO/RD and OS/RD were, respectively, .477 and .546, which compared rather well with the average correlation of .528 among the seven RD scores. When these ratings were pooled, the reliability coefficient using the Spearman-Brown formula was .913. The attribute requirements of these ratings were then isolated and these indicated that cognitive skills, visual perception/interpretation, and quantitative skills were critical to performance within this tactical command and control workstation.

### RECOMMENDATIONS

Since the translational procedure outlined in this paper is more efficient than the proposed method of collecting PAQ ratings, it is recommended that future analyses of Navy jobs, Ratings, and workstations utilize this method on existing task inventories. Secondly, the attribute requirements of the Combat Information Center that were outlined in this paper should become the basis for determining generic batteries of tests. In this way, human performance assessment would be more relevant to Navy jobs.



### ACKNOWLEDGEMENTS

The author would like to acknowledge the efforts of LCDR Carter who requested the Radarman Ratings analyses from PAQ Services.

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The work was funded by the Naval Medical Research and Development Command and by the Biological Sciences Division of the Office of Naval Research.

## Abstract

Two task inventories, Combat Information Control Officer (CICO) in the E2 aircraft and the Operations Specialist Rating (OS) containing respectively 249 and 325 tasks, were translated into structured job elements of the Position Analysis Questionnaire (PAQ). Both of these rating profiles represented functions performed in Naval Combat Information Centers by 35 (CICO) and 1909 (OS) people. The adequacy of the translation was determined through a correlational comparison with other PAQ profiles from similar jobs. Seven sets of Radarman Rating (RD) scores were provided by PAQ Services from their computer files. The average correlation between CICO/RD and OS/RD were, respectively, .477 and .546, which compared rather well with the average correlation of .528 among the seven RD scores. When these ratings were pooled, the reliability coefficient using the Spearman-Brown formula was .913. The attribute requirements of these ratings were then isolated and these indicated that cognitive skills, visual perception/interpretation, and quantitative skills were critical to performance within the tactical command and control workstation.

NBDL - 82R007

# TRANSLATION OF FUNCTIONAL TASKS OF A NAVAL WORKSTATION TO STRUCTURED JOB ELEMENTS

RICHARD H. SHANNON

MARCH 1982

Bureau of Medicine and Surgery
Work Unit No. MF58.524-02E-0002

Approved by

Channing L. Ewing, M. D.
Chief Scientist

Released by

Captain L. E. Williams, MC USN
Commanding Officer

Naval Biodynamics Laboratory
Box 29407
New Orleans, LA 70189

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## Introduction

In the past year, there has been an increasing interest in structured job analysis techniques at the Naval Biodynamics Laboratory (Shannon & Carter, 1981; Shannon, Carter, & Boudreau, 1981; Carter, Patsfall, & Shannon, 1982) The goal of the research effort has been to isolate the critical components and behavioral attributes of functions performed by Navy personnel in essential jobs for the purpose of developing batteries of psychological tests. The initial thrust has been with the functions performed within the Combat Information Center (CIC) workstation because of its importance to overall tactical control and mission success of a naval task force. In the initial studies of officer and enlisted functions within the air and sea environments, there were high correlations between functions. This paper will extend these studies in three ways: (1) outline a procedural process that can translate specific job tasks into standardized ratings on a structured questionnaire, (2) compare these CIC analyses with other sources of CIC functions, and (3) specify attribute requirements within this tactical workstation for purposes of battery development. These generic batteries can then be used at NBDL to assess human performance under actual or simulated environments involving ship motion, impact, and vibration.

## Position Analysis Questionnaire

Essential to this line of research is the Position Analysis Questionnaire (PAQ) developed by McCormick, Jeanneret, and Mecham (1972). The PAQ is a structured job analysis questionnaire that is composed of 194 job elements. In general, "extent of use" and "importance to the job" having anchor points from 0 to 5 are the two scales that are most frequently used. The elements are of a worker-oriented nature that tend to imply human activities that are involved in jobs. The job elements in PAQ are organized in the following six divisions: information input, mental processing work output, relationships with others, job context, and other job characteristics. The PAQ element scores are converted to 45 job factor scores by using factor loadings and weights developed for 2200 jobs (Mecham, McCormick, & Jeanneret, 1977). The 45 factors (dimensions) include 33 and 12, respectively, for the six divisions analyzed separately and combined.

The PAQ is being used at this laboratory to establish a procedure for developing psychological batteries which will have synthetic, component or construct validity. The concept of job component validity assumes that the human requirements of any given job are comparable with other jobs having equal amounts of similar work activities (McCormick, 1979). The procedure for establishing validity includes: (a) identification of the work functions and their relative importance, (b) determination of human attributes associated with successful performance of the work functions, and (c) combination of the attribute requirements associated with each function into an estimate of the requirements for the entire job. If the job component validation is successful, then the human attributes and work functions acquire construct validity. Of course, a job component validity effort presumes that a taxonomy of work functions and a method for measuring all relevant human attributes are available. Both of these needs can be met through the use of the PAQ and the proper selection of psychological tests to measure human attributes.

Another study by McCormick and his associates at Purdue University (Marquardt & McCormick, 1972 ) was of assistance in determining the attribute requirements of a job. In this study, between 8 -11 experts (psychologists who were members of APA) were asked to rate the relevance of 49 human attributes of an "aptitude" nature to 182 of the 194 items in the structured Position Analysis Questionnaire (PAQ). The following twelve PAQ numbered elements were not analyzed because they were open-ended with any response being possible: 44, 60, 127, 160, 181, 188 -194. A 6-point scale (0 -5) involving "the degree of relevance of an attribute to a job element" was used. The reliability coefficients of the pooled ratings for these attributes ranged from .796 to .964. The 49 abilities used in this analysis were very similar to abilities or attributes listed in other studies in the literature (Theologus, Romashko, & Fleishman, 1970; Pawlik, 1966; Ekstrom, French, Harman, & Derman, 1976). Appendix A contains a list of these 49 abilities with definitions. In addition, Appendix B depicts the following seven factor model resulting from a principal components analysis and varimax rotation of the matrix containing 49 attributes by 182 PAQ elements (McCormick, 1979):

1) general physical skills
2) cognitive skills
3) visual perception/interpretation
4) psychomotor skills
5) chemical senses
6) physical response/coordination versus imaginative orientation
7) quantitative skills

Task Analysis Inventories

McCormick (1979) lists the following twelve methods of collecting job-related information: observation, individual interview, observation-interview, group interview, technical conference, structured questionnaire, open-ended questionnaire, diary, critical incidents, equipment design, recordings of job activities, and records. Information pertaining to the Combat Information Control Officer (CICO) in the E2 Early Warning aircraft was obtained using a combination of these methods. Most of the job related data was gathered from a structured job questionnaire consisting of 249 tasks (Shannon, 1980 ; NAMRL, 1972). Content validity was established using subject-matter experts and existing task descriptions for the inventory development. Two seven-point scales were used in the functional inventory to measure either the required proportion of time and effort (Part of Position) or the importance (Criticality) of each task/duty/role relative to the remaining tasks, duties, roles. These questionnaires were mailed to the appropriate squadrons, and upon their return, this information was coded, keypunched, and analysed. A "Part of Position" and "Criticality" mean and standard deviation were computed for each role, duty, and task. A sample of 35 naval flight officers completed the questionnaire (NAMRL, 1972). These results were analyzed in this paper using the PAQ in order to determine attribute requirements within the Combat Information Center of Navy aircraft.

Another source of Combat Information Center functions is the Operations Specialist (OS) Rating task inventory developed by the Navy Occupational Development and Analysis Center (NODAC, April 1977; May 1977). This unit has developed job task inventory questionnaires for every Naval rating. These questionnaires are administered to a representative sample of personnel in a given rating (between 18 -23%). Initially, various sources of job information (NEC manuals, rate training manuals) are reviewed in order to familiarize the individuals developing the inventory with work content of the rating. In addition, inventory development is also assisted through observation and interview of job incumbents at the work area. From these various sources, a job task inventory is produced and administered to the Fleet by the NOTAP team. The OS rating inventory consisted of 325 tasks, and was completed by 1909 people at all rate levels. These individuals completed these questionnaires by estimating the amount of time spent on each task on a 5 point scale. These data were also analyzed using the PAQ.

## Translation of Job Tasks into Job Elements

Most PAQ analyses of jobs involve trained analysts interviewing various incumbents, who are experienced with a particular job/position (Mecham et al., 1977). This procedure can be slow, costly and disruptive of the job (Levine, Ash, & Bennett, 1980). A recent study (Jones, Main, Butler, & Johnson, 1981) has attempted to determine whether trained raters could convert written job descriptions to ratings using the PAQ. The authors believed that a technique which could translate existing narrative descriptions to PAQ ratings without having to perform interviews between analysts and incumbents would be highly valuable. One observed problem with this approach was that the reliability of element ratings was generally low. However, interrater agreement tended to improve as items were combined into job dimensions. Therefore the authors concluded that the results were encouraging, and that reliable and valid scores could be attained from job descriptions.

## Purpose

The purpose of the present study is to determine whether the data from the CICO and OS task inventories can be converted using a systematic procedure into PAQ job element ratings. This information would be compared with another but similar source of Combat Information Center ratings in order to determine if this methodology can result in reasonable reliabilities. The other source of data is the seven PAQ analyses conducted by McCormick and his associated of the Radarman (RD) Rating. This information is stored in the PAQ Services computer (Mecham et al., 1977). A second purpose of this paper is to analyze these job elements for attribute requirements involved in various sources of Combat Informaion Center duties when acceptable reliability is established for these two sets of job related data. These requirements would then form the basis for recommended batteries of tests that would measure performance in a generic workstation involving tactical command and control tasks.

## Method

This section of the paper outlines the following procedural steps of translating functional job tasks into attribute requirements:

1) Content analyses of task inventories
2) PAQ analyses of essential tasks
3) Correlational analyses of task to element translations
4) Critical PAQ elements and dimensions
5) Attribute requirements for a tactical workstation

## Content Analyses of OS and CICO Task Inventories

Each of the 249 tasks within the CICO task inventory was rank-ordered by a "Part of Position" and "Criticality" mean. Those tasks which were rated as 70 percent or higher on both scales were isolated for further analysis. This filtering technique separated 45 tasks from the total inventory. These tasks are considered to be the most essential to CICO performance. A content analysis was then performed using the action verbs and goal-oriented behavior of these 45 tasks as the basis for synthesis to the 10 tasks outlined in Appendix C. These tasks represent 30 percent of the total time utilized by 35 people on the 249 items of the total inventory. This percentage was determined by dividing the total sum of ratings on 45 tasks by 249 tasks on the "Part of "Position" or time/effort scale. In Appendix C, next to each of the 10 tasks is a percentage of the 45 essential tasks contained within that specific item. The percentages summed to 100 percent. In this way the relative weight of each of the 10 tasks is known.

The 325 tasks in the OS Rating inventory were rank-ordered as to the amount of time spent on each task. Ninety-eight tasks were isolated as rating 70 percent or higher on this five point scale. After inspecting the tasks for content, another 31 tasks were separated from the critical pool of tasks because they were non-CIC related. A content analysis of the remaining 67 tasks was performed using goal-orientations and action verbs. The 11 tasks with their respective percentages of contained tasks are listed in Appendix D. These essential tasks represent 51 percent of the total time spent by 1909 people within a total inventory of 325 tasks.

## PAQ Analyses of OS and CICO Task Inventories

Most of the 194 elements of the structured PAQ questionnaire could be used in the following analyses of the functional tasks. A simple question was asked on each of the 10 CICO and 11 OS combined task inventories: "Is this PAQ job element used or important within this task?" A "yes" answer on a five-point scale equated to a rating of 2.5 - 5.0, while a "no" represented a 0 - 2.49 rating. For each "yes" answer, the percent for that task was assigned to the job element. The percentages within a PAQ job element were then summed to give a total score for that element. These percentages when multiplied by 5 were transformed into estimates of PAQ ratings on a five-point scale.

The following element scores could not be determined in this fashion: 20, 36, 37, 38, 44, 46, 47, 48, 49, 60, 87, 88 - 92, 112, 128, 129, 130, 134, 135 - 142, 143, 144 - 147, 153, 154 - 168, 181, 182, 183, 184, 185, 186, 187, 184 - 194. An overall job rating for these 68 elements was determined by either: (1) assigning an overall job score based upon reading the tasks and/or prior knowledge of the job; or (2) assigning individual ratings to each OS and CICO task computing a weighted job-mean (using percentages as weights) from these scores.

## Correlational Analyses of Task to Element Translations

Mecham et al. (1977) outline a means of tapping the computer files of PAQ Services. This data bank contains information on numerous civilian and military occupations and jobs. The Radarman Rating (RD, the old name for the Operations Specialist Rating) is one of the jobs contained in this file. In 1972, four analysts completed seven PAQ analyses (three RD3, three RD2, and one RD1) with Navy personnel who represented three different rates (first, second, and third class) of the RD Rating onboard the U.S.S. Independence and U.S.S. Intrepid (two Navy carriers). The OS and CICO task inventories were correlated with the seven RD PAQ profiles provided by PAQ Services. A moderate to high correlation would indicate that the method of translating functional tasks to PAQ elements was successful. The average pairwise correlation for the nine sets of 194 job element ratings (36 correlations) is an estimate of the reliability of each set of ratings. If the average correlation is placed in a Spearman-Brown formula, the result is a pooled reliability coefficient for nine separate analyses of CIC functions and tasks.

A tenth set of ratings will also be used in this study. A PAQ analysis of the NTDS and AEGIS ship systems was conducted at this laboratory (Sh[illegible] & Carter, 1981). The original task inventory contained approximately 300 tasks, which outlined the duties of 28 separate positions (enlisted and officer) within CIC. This information had been published in procedural handbooks (AEGIS Department, June 1980) and was collated into one overall task inventory. The PAQ ratings were then determined using this inventory as a reference. The procedural steps outlined for the OS and CICO ratings were not followed in the AEGIS analysis. This set of ratings will also be compared with the other nine sets. If the correlations are moderate to high, these scores will also be pooled with the other scores.

## Critical PAQ Elements and Dimensions

One of the purposes of this study is to determine generic batteries of tasks based upon the overall attribute requirements of a tactical command and control workstation. In order to do this, a pooled mean of the ten PAQ analyses for 182 job elements was computed. Twelve scores (44, 60, 127, 160, 181, 188 - 194) were not used again in this study because they did not have an attribute profile. Using the factorial structure outlined by Mecham et al. (1977), the PAQ elements were grouped into dimensions. The mean of each dimension (sample mean) was compared with the population mean (all 182 ratings) using a t-test corrected for sampling from a finite population. In this way significant dimensions were determined using an alpha level of .1, one-tail. Within these dimensions an element having a rating of 2.5 and above (midpoint on a 0 -5 scale) was considered critical. Appendix E contains the significant dimensions and critical elements of these various sources of CIC functions.

## Attribute Requirements for a Tactical Workstation

The attribute profiles (Marquardt & McCormick, 1972) were added together across the 52 critical elements. These scores represented the sample means for each of the 49 attributes while the population means were computed across the 182 elements. T-tests were performed using .005, one-tail as the level of significance and a correction for sampling from a finite population. Appendix F contains the significant attributes and attribute dimensions, which become

the basis for outlining generic batteries of tests for performance evaluation within a tactical workstation.

## Results

### Comparison of OS and CICO Task Inventories

Although both inventories (Appendices C, D) were prepared by different agencies (NAMRL, 1972; NODAC, April 1977) and the tasks are performed by different ranks (officer, enlisted) in different environments (air, sea), there are very similar duties performed by both groups. The communication and coordination of appropriate tactical and navigational information to own crew personnel and/or with other ships and aircraft using the radar sensor and radios as the main sources of information gathering and distribution are essential to both jobs. Further, the high correlation (.758) between both sets of PAQ ratings further supports the similarity of functions. These two statements lend credibility to the idea that jobs with similar mission orientations have high commonality of human work functions. The apparent reason for the similarities is that the two jobs involve military tactical control functions whose rudiments consist of command, control, communication and coordination of personnel and equipment. It is hypothesized that when PAQ comparisons are conducted on other jobs which reflect similar characteristics, the results will indicate strong similarities to the two jobs just described.

### Comparison of OS and CICO Tasks with Radarman Rating

Table 1 depicts the intercorrelations between the ten sets of 190 PAQ ratings. Items 44, 60, 127, and 181 were removed from this analysis because they are open-ended questions. Five conclusions can be drawn from the matrix: 1) the seven correlations between the OS, CICO, and AEGIS ratings and the seven sets of Radarman scores remained rather consistent when compared with the average correlations (OS/RD $r = .546$, CICO/RD $r = .477$, AEGIS/RD $r = .552$); (2) the 21 correlations among the seven RD scores remained rather consistent when compared with the average correlation ($r = .528$); (3) the average correlations among the OS/RD, CICO/RD and AEGIS/RD ratings compared favorably with the average correlation among the RD scores; (4) the six correlations among the four sets of ratings (OS, CICO, AEGIS, RD) were rather consistant and had an average correlation of .725; and (5) the pooled reliability across these four sets of scores as determined by the Spearman-Brown formula were quite high ($r_p = .913$). It can be summarized from these results that the translations of functional tasks to PAQ ratings on both the CICO and OS jobs were successful.

### Analyses of PAQ dimensions, Elements and Attributes

Appendix E lists the eleven significant dimensions (.1, one-tail) of this study. The dimensions indicate that performance and environmental conditions within a Naval tactical command and control workstation can be defined generically by: vigilant/discriminating work activities and job demanding responsibilities; decision making, and information processing; input from representational sources and environmental awareness; using machines/tools/equipment, job-related communications; and working non-typical schedules in non-businesslike situations wearing specified apparell. Within these dimensions, 52 elements are considered critical with ratings of 2.5 and above. Significant dimensions in this paper were determined by comparison within a rating

Table 1: Correlations Between Ten Different Sets of 190 PAQ Ratings

| PAQ Sets* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | .758 | | | | | | | | | |
| 3 | .583 | .673 | | | | | | | | |
| 4 | .495 | .621 | .607 | | | | | | | |
| 5 | .497 | .568 | .540 | .639 | | | | | | |
| 6 | .398 | .513 | .570 | .574 | .657 | | | | | |
| 7 | .474 | .430 | .567 | .457 | .451 | .569 | | | | |
| 8 | .342 | .467 | .550 | .439 | .523 | .513 | .367 | | | |
| 9 | .588 | .648 | .476 | .567 | .632 | .590 | .421 | .389 | | |
| 10 | .781 | .770 | .574 | .571 | .576 | .497 | .522 | .413 | .712 | |
| 11 | .618 | .712 | - | - | - | - | - | - | - | .713 |

* PAQ Set numbers represent:

1) CICO (E2 aircraft)
2) OS Rating
3) RD3 (Radarman Rating, third class)
4) RD3
5) RD3
6) RD2 (Radarman Rating, second class)
7) RD2
8) RD2
9) RD1 (Radarman Rating, first class)
10) AEGIS/NTDS (surface ship)
11) Pooled RD score (N=7)

profile. Each dimension and its elemental ratings were viewed as samples from the general population of total ratings. This method is different from the one outlined by Mecham et al. (1977). They computed a dimension's Z score by comparing a dimension score with the population of scores on that dimension from 2200 jobs. The statistical method in this paper is suitable for its goals: that of developing batteries of psychological tests utilizing a synthetic validity approach to isolate the required attributes of a particular job or workstation. This purpose is quite different from the more universal goals outlined by Mecham et al. (1977) which are more dependent upon comparisons across jobs.

Appendix F outlines ten significant attributes at the .005 level, one-tail for the ten pooled sets of ratings. When these attributes are grouped by the seven attribute dimensions discussed in Appendix B, the following dimensions emerge as being the most essential to performance in the tactical workstation of this paper: cognitive skills, visual perception/interpretation,

and quantitative skills. The critical attributes for the RD3/RD2, RD1 and OS jobs which were determined by the statistical analyses of PAQ Services and requested by this laboratory, indicated somewhat similar results. The RD3/RD2 analysis depicted the visual perception/interpretation dimension to be most important, while both the RD1 and OS jobs resulted in the cognitive skills dimension being the most important. In addition, the PAQ analyses indicated that the following four tests in the General Aptitude Test Battery (GATB) would be useful in a selection battery for these three jobs: clerical perception, numerical aptitude, spatial perception, and intelligence. In general, the results of both analyses seem to agree at the attribute dimension level.

## Discussion

A purpose of this study was to determine whether data from task inventories using a procedure outlined in this paper could be translated into job element ratings using the Position Analysis Questionnaire. The two inventories that were used contained pooled information of 35 and 1909 people. After these functional tasks were translated into job elements, the effectiveness of the methodology was determined through correlational analyses with information provided by PAQ Services about seven people in the Radarman Rating. The results indicated that the methodology was successful; and therefore, the data was pooled into one set of PAQ ratings. This information was then used to isolate critical attributes of a generic tactical command and control workstation in order to specify test batteries for human performance evaluation. The findings in this paper are considered important to future research at this laboratory because:

1) an efficient, reliable, and valid procedural methodology is outlined which can translate functional tasks into structured job elements.

2) a workable synthetic validity approach is described which can isolate attributes important to Navy jobs and tasks.

The procedure of translating tasks into elements is more significant when one considers that it represents the pooled data of numerous individuals (OS = 1909, CICO = 35). Data are now presently stored in computer files, such as NODAC. Further, the recommended procedure of collecting PAQ ratings can be slow, costly, and disruptive of the job. The method outlined in this paper is considered to be more efficient and did provide similar results as indicated by the intercorrelational matrix.

Two batteries of tasks (Shannon, 1982; Shannon, Carter, & Boudreau, 1981) have been analyzed at this laboratory that are purported to contain attributes critical to duties performed in a tactical command and control workstation. One set of seven tests (Shannon, 1982) measured perceptual, cognitive, and quantitative constructs, while the second group of seven tests (Shannon, Carter, & Boudreau, 1981) was composed mainly of visual perception tasks. Fifteen alternate forms for each test were developed and evaluated in order to determine test reliabilities and stable periods of performance. The tests were given each day over a 15 day period. Four tests in the first battery, and seven tests in the second battery demonstrated differential stability, and moderate to high reliabilities after a period of practice. These eleven tests were, therefore, considered appropriate for future research at this laboratory. These tests were: Hidden Figures, Form Board, Vertical Addition, Maze

Tracing (first battery); Errors in Prose, Number Comparison, Pattern Comparison, Pattern Recognition, Number Search, Letter Search, and Military Vehicles (second battery).

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# APPENDIX A

## Definitions of the 49 Attributes of an "Aptitude" Nature Outlined in Marquardt and McCormick (1972)

Definitions of the 49 Attributes of an "aptitude" nature

1. Verbal comprehension: Ability to understand the meaning of words and ideas associated with them.

2. Work fluency: Ability to rapidly produce words associated with a given word.

3. Oral communication: Ability to communicate ideas with gestures or with spoken or written words.

4. Numerical computation: Ability to manipulate quantitative symbols rapidly and accurately, as in various arithmetic operations.

5. Arithmetic reasoning: Ability to reason abstractly using quantitative concepts and symbols.

6. Convergent thinking: Ability to select from possible alternative methods, the method of processing information that leads to the potentially best answer or solution to a problem.

7. Divergent thinking: Ability to generate or conceive of new or innovative ideas or solutions to a problem.

8. Intelligence: The level of abstraction or symbolic complexity with which one can ultimately deal.

9. Long-term memory: Ability to learn and store pertinent information and selectively to retrieve or recall, much later in time, that which is relevant to a specific context.

10. Short-term memory: Ability to learn and store pertinent information and selectively to retrieve or recall, within a brief period of time, that which is relevant to a specific context.

11. Asthetic judgment: Ability to make sensitive evaluations of artistic quality in one or more of the following: music, style, painting, sculpture, photography, architecture, etc.

12. Visual form perception: Ability to perceive pertinent detail or configuration in a complex visual stimulus.

13. Perceptual speed: Ability to make rapid discriminations of visual detail.

14. Closure: Ability to perceptually organize a chaotic or disorganized field into a single perception.

15. Movement detection: Ability to detect physical movement of objects and to judge their direction.

16. Spatial visualization: Ability to manipulate visual images in two or three dimensions mentally.

17. Near visual acuity: Ability to perceive detail at normal reading distance.

18. Far visual acuity: Ability to perceive detail at distances beyond normal reading distance.

19. Depth perception: Ability to estimate depth of distances or objects (or to judge their physical relationships in space).

20. Color discrimination: Ability to perceive similarities or differences in colors or in shades of the same color, or to identify certain colors.

21. Auditory acuity: Ability to perceive relevant cues by sound.

22. Olfactory acuity: Ablity to perceive relevant cues by smell.

23. Gustatory acuity: Ability to perceive relevant cues by taste.

24. Tactual acuity: Ability to perceive relevant cues by touch.

25. Body orientation: Ability to maintain body orientation with respect to balance and motion.

26. Kinesthesis: Ability to sense position and movement of body members.

27. Finger dexterity: Ability to manipulate small objects (with the fingers) rapidly and accurately.

28. Manual dexterity: Ability to manipulate things with the hands.

29. Arm/hand positioning: Ability to make precise, accurate movements of the hands and arms.

30. Arm/hand steadiness: Ability to keep the hands and arms immobilized in a set position with minimal tremor.

31. Continuous muscular control: Ability to exert continuous control over external devices through continual use of body limbs.

32. Rate of arm movement: Ability to make gross, rapid arm movements.

33. Eye-hand coordination: Ability to coordinate hand movements with visual stimuli.

34. Eye-hand-foot coordination: Ability to move the hand and foot coordinately with each other in accordance with visual stimuli.

35. Simple reaction time: The period of time elapsing between the appearance of any stimulus and the initiation of an appropriate response.

36. Response integration: Ability to rapidly perform various appropriate psychomotor responses in proper sequence.

37. Dynamic strength: Ability to make repeated, rapid, flexing movements in which the rapid recovery from muscle strain is critical.

38. Static strength: Ability to maintain a high level of muscular exertion for some minimum period of time.

39. Explosive strength: Ability to expend a maximum amount of energy in one or a series of explosive or ballistic acts (as in throwing, pounding, etc.).

40. Rate control: Ability to make continuous anticipatory motor adjustments, relative to change in speed and direction of continuous moving objects.

41. Mechanical ability: Ability to determine the functional interrelationships of parts within a mechanical system.

42. Ideational fluency: Ability to produce a number of ideas concerning a given topic. This attribute is only concerned with the number of ideas produced and does not extend to the quality of those ideas.

43. Originality: Ability to produce unusual or clever responses related to a given topic or situation. This attribute is concerned with the degree of creativity of responses and does not deal with the number of responses made.

44. Problem sensitivity: Ability to recognize or identify the existence of problems. This attribute does not include any of the reasoning necessary for the solution of a problem.

45. Spatial orientation: Ability to maintain one's orientation with respect to objects in space or to comprehend the position of objects in space with respect to the observer's position.

46. Selective attention: Ability to perform a task in the presence of distracting stimulation or under monotonous conditions without significant loss in efficiency.

47. Time sharing: Ability to utilize information obtained by shifting between two or more channels of information. The information obtained from these sources is either integrated and used as a whole or retained and used separately.

48. Stamina: This ability involves the capacity to maintain physical activity over prolonged periods of time. It is concerned with the resistance of the cardio-vascular system to breakdown.

49. Speed of limb movement: This ability involves the speed with which discrete movements of the arms or legs can be made. The ability deals with the speed with which the movement can be carried out after it has been initiated; it is not concerned with the speed of initiation of the movement.

# APPENDIX B

The Seven Attribute Dimension Structure Resulting from the Principal Components Analysis and Varimax Rotation of the Matrix Containing 49 Attributes by 182 Elements (Information contained in Marquardt & McCormick (1972) and McCormick (1979)).

The seven components or attribute dimensions resulting from a principal components analysis and varimax rotation which explains 83.3% of the total variance are:

1. General Physical Skills
2. Cognitive Skills
3. Visual Perception/Interpretation
4. Psychomotor Skills
5. Chemical Senses
6. Physical Response/Coordination Versus Imaginative Orientation
7. Quantitative Skills

Each of these seven dimensions, their attributes and loadings, their job elements, and Z-scores are outlined in the following paragraphs under their own headings. A loading on an attribute of .50 is considered to be a substantial correlation with a dimension. A score on an element of 1.65 (.05, one-tail) is viewed as being significantly related to a dimension. The numbers of each attribute and element coincide with their sequential order, respectively, in Appendix A or in the PAQ.

1. General Physical Skills (26.8% of the Variance)

| A. Attributes | Loadings |
|---|---|
| 37. Dynamic strength | .93 |
| 38. Static strength | .93 |
| 49. Speed of limb movement | .91 |
| 39. Explosive strength | .89 |
| 26. Kinesthesis | .88 |
| 32. Rate of arm movement | .85 |
| 31. Continuous muscular control | .84 |
| 48. Stamina | .83 |
| 34. Eye-hand-foot coordination | .82 |
| 25. Body orientation | .81 |
| 36. Response integration | .80 |
| 29. Arm/hand positioning | .75 |
| 33. Eye-hand coordination | .73 |
| 30. Arm/hand steadiness | .70 |
| 24. Tactual acuity | .69 |
| 28. Manual dexterity | .65 |
| 40. Rate control | .56 |
| 45. Spatial orientation | .52 |
| 27. Finger dexterity | .51 |

| B. Job Elements | Score Range |
|---|---|
| 85, 86 | 2.58 & above |
| 53, 70, 75, 91 | 1.96 - 2.57 |
| 51, 52, 55, 68, 72, 74, 76, 83, 84, 87, 96, 110, 111 | 1.65 - 1.95 |

2. Cognitive Skills (22.3% of the Variance)

| A. Attributes | Loadings |
|---|---|
| 8. Intelligence | .92 |
| 47. Time-sharing | .87 |
| 9. Long-term memory | .87 |
| 1. Verbal comprehension | .86 |
| 44. Problem sensitivity | .86 |
| 10. Short-term memory | .86 |
| 6. Convergent thinking | .82 |
| 3. Oral communication | .82 |
| 2. Word fluency | .81 |
| 42. Ideational fluency | .79 |
| 43. Originality | .77 |
| 7. Divergent thinking | .77 |
| 46. Selective attention | .74 |
| 5. Arithmetic reasoning | .66 |
| 14. Closure | .60 |
| 21. Auditory acuity | .58 |

| B. Job Elements | Score Range |
|---|---|
| 37, 39, 40, 100 | 1.96 - 2.57 |
| 36, 99, 101, 102, 105, 116, 152 | 1.65 - 1.95 |

3. Visual Perception/Interpretation (18.5% of the Variance)

| A. Attributes | Loadings |
|---|---|
| 12. Visual form perception | .90 |
| 16. Spatial visualization | .89 |
| 19. Depth perception | .82 |
| 20. Color discrimination | .82 |
| 18. Far visual acuity | .81 |
| 13. Perceptual speed | .80 |
| 17. Near visual acuity | .74 |
| 45. Spatial orientation | .72 |
| 41. Mechanical ability | .69 |
| 15. Movement detection | .67 |
| 14. Closure | .61 |
| 40. Rate control | .50 |

| B. Job Elements | Score Range |
|---|---|
| 10, 14, 22 | 2.58 & above |
| 3, 5, 11, 12, 13, 21, 29, 176, 178 | 1.96 - 2.57 |
| 8, 20, 23, 31, 32, 34, 74, 177 | 1.65 - 1.95 |

4. Psychomotor Skills (5.9% of the Variance)

| A. Attributes | Loadings |
|---|---|
| 27. Finger dexterity | .75 |
| 28. Manual dexterity | .64 |
| 30. Arm/hand steadiness | .59 |
| 29. Arm/hand positioning | .56 |

| B. Job Elements | Score Range |
|---|---|
| 50, 56, 93 | 2.58 & above |
| 54, 58, 59, 65, 109 | 1.96 - 2.57 |
| 6, 43, 95, 98, 174 | 1,65 - 1.95 |

5. Chemical Senses (3.8% of the Variance)

| A. Attributes | Loadings |
|---|---|
| 23. Gustatory acuity | .92 |
| 22. Olfactory acuity | .88 |

| B. Job Elements | Score Range |
|---|---|
| 18, 19, 111, 145, 146, 147 | 2.58 & above |
| 138 | 1.96 - 2.57 |
| 31 | 1.65 - 1.95 |

6. Physical Response/Coordination Versus Imaginative Orientation (3.7% of the Variance)

| A. Attributes | Loadings |
|---|---|
| 35. Simple reaction time | .60 |
| 11. Aesthetic judement | -.61 |

| B. Job Elements | Score Range |
|---|---|
| 28, 29, 98, 178 | 1.96 - 2.57 |
| 30, 143 | 1.65 - 1.95 |

7. Quantitative Skills (3.3% of the Variance)

| A. Attributes | Loadings |
|---|---|
| 4. Numerical computation | .71 |
| 5. Arithmetic reasoning | .53 |

| B. Job Elements | Score Range |
|---|---|
| 2, 6, 49 | 2.58 & above |
| 1, 33, 35, 37, 38, 40, 184 | 1.96 - 2.57 |
| 39 | 1.65 - 1.95 |

# APPENDIX C

Tasks Frequently Performed by the Combat Information Control Officer (CICO) in the E-2 Aircraft (45 tasks collapsed to 10 tasks representing 30% of the total work time of 35 people in a total inventory of 249 tasks)

| Combat Information Control Officer Tasks | % of 45 Tasks |
|---|---|
| 1. Monitor, supervise, and receive information using data link. | 4.4 |
| 2. Direct, recommend, coordinate, inform the crew of tactical information using ICS. | 8.9 |
| 3. Communicate with tactical controlling agencies and participating units using UHF/HF radios by monitoring all transmissions and exhanging tactical/emergency information. | 22.2 |
| 4. Monitor and interpret information from IFF/SIF interrogator equipment. | 4.4 |
| 5. Coordinate intelligence collection and dissemination for mission briefs and debriefs. | 6.7 |
| 6. Monitor, search for, acquire, evaluate and track targets using radar. | 11.1 |
| 7. Coordinate search and surveillance by determining best tactic, sensor, and sensor mode and by being aware of friendly force ship and aircraft dispositions. | 11.1 |
| 8. Coordinate target detection, localization and attack by monitoring and directing multi-targeted situations during strike missions and weapons launch. | 13.4 |
| 9. Inspect aircraft during preflight/postflight to ensure integrity of airplane and to check system/subsystem operation. | 6.7 |
| 10. Assess system status throughout flight by monitoring status of all equipment and determining feasibility of mission completion. | 11.1 |

# APPENDIX D

Tasks Frequently Performed by the Operations Specialist Rating (OS) in the Combat Information Center (CIC) Onboard Navy Ships (67 tasks collapsed to 11 tasks representing 51% of the total work time of 1909 people in a total inventory of 325 tasks)

| Operations Specialist Tasks | | % of 67 Tasks |
|---|---|---|
| 1. | Select/adjust appropriate controls on radar equipment. | 6.0 |
| 2. | Set-up the DRT/NCS by using appropriate coordinate/plotting system (scales, Lat/Long, grid). | 4.5 |
| 3. | Coordinate/supervise the work of CIC personnel | 7.5 |
| 4. | Communicate appropriate navigational and tactical information to the bridge, within CIC or to other tactical units. | 16.4 |
| 5. | Use appropriate secure communications on radiotelephone circuits. | 3.0 |
| 6. | Plot/maintain the surface picture on the DRT/NC2 and radar | 16.4 |
| 7. | Compute essential navigational information using radar and DRT/NC2. | 17.8 |
| 8. | Compute essential navigational information using maneuvering board. | 10.4 |
| 9. | Plot appropriate information on navigational charts. | 3.0 |
| 10. | Maintain navigational information in logs and on status boards. | 9.0 |
| 11. | Obtain appropriate tactical and navigational information using radar. | 6.0 |

# APPENDIX E

## Significant Dimensions and Critical Elements from a PAQ Analysis of Various Combat Information Center Workstations

A. Information Input Dimensions and Elements:*

2. Using Various Sources of Information (2.58**)

| | | |
|---|---|---|
| 15. | Verbal sources*** | (4.12) |
| 20. | Near-visual differentiation | (3.91) |
| 3. | Pictorial materials | (3.67) |
| 35. | Estimating time | (3.60) |
| 1. | Written materials | (3.13) |
| 12. | Behavior | (2.88) |
| 2. | Quantitative materials | (2.70) |

5. Being Aware of Environmental Conditions (1.42)

| | | |
|---|---|---|
| 13. | Events or circumstances | (4.02) |
| 11. | Man-made features of environment | (3.81) |
| 29. | Estimating speed of moving objects | (3.31) |
| 21. | Far visual differentiation | (3.20) |
| 34. | Estimating size | (2.94) |
| 12. | Behavior | (2.88) |
| 10. | Features of nature | (2.74) |
| 22. | Depth perception | (2.61) |

B. Mental Processes Dimensions and Elements:

7. Making Decisions (2.78)

| | | |
|---|---|---|
| 40. | Analyzing information or data | (4.42) |
| 39. | Combining information | (4.30) |
| 41. | Compiling | (3.65) |
| 38. | Amount of planning/scheduling | (3.55) |
| 37. | Reasoning in problem solving | (3.50) |
| 36. | Decision making | (3.47) |
| 48. | Training | (2.92) |

8. Processing Information (3.14)

45. Short-term memory (4.52)

40. Analyzing information or data (4.42)

39. Combining information (4.30)

43. Transcribing (3.74)

41. Compiling (3.65)

37. Reasoning in problem solving (3.50)

42. Coding/decoding (2.69)

C. Work Output Dimensions and Elements:

9. Using Machines/Tools/Equipment (2.16)

63. Fixed setting controls (4.03)

64. Variable setting controls (3.86)

62. Activation controls (3.77)

78. Setting up - adjusting (3.53)

66. Hand-operated controls, frequent (3.28)

D. Relationships with Other Persons Dimensions and Elements:

20. Exchanging Job-Related Information (1.45)

104. Routine information exchange (4.09)

112. Job-required personal contact (3.80)

102. Instructing (3.54)

115. Supervising (3.4[illegible])

F. Other Job Characteristics Dimensions and Elements:

25. Working Non-Typical Schedule (2.87)

168. Typical day and night hours (5.0 or [illegible])

155. Specific uniform/apparel (4.[illegible] or .54)

165. Irregular hours (?.[illegible] 6)

26. Working in a Non-Businesslike Situation (2.22)

| | | |
|---|---|---|
| | 156. Work clothing | (4.50 or .9) |
| 27. | Wearing Specific Apparel | (3.31) |
| | 155. Specific uniform/apparel | (4.20 or .84) |
| 30. | Working Under Job-Demanding Circumstances | (3.88) |
| | 176. Recognition | (4.84) |
| | 175. Attention to detail | (4.42) |
| | 174. Precision | (4.40) |
| | 187. Criticality of position | (4.05) |
| | 180. Updating job knowledge | (3.94) |
| | 173. Time pressure of situation | (3.62) |
| | 185. General responsibility | (3.60) |
| | 179. Working under distractions | (3.14) |
| | 186. Job structure | (2.63) |
| 32. | Being Alert to Changing Conditions | (3.71) |
| | 176. Recognition | (4.84) |
| | 177. Vigilance: infrequent events | (4.57) |
| | 178. Vigilance: continually changing events | (4.49) |
| | 184. Responsibility for material assets | (3.70) |
| | 185. General responsibility | (3.60) |
| | 182. Travel | (3.50) |
| | 183. Responsibility for the safety of others | (3.38) |

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* Divisions listed in PAQ sequential order from A - F

** Significant dimensions listed in PAQ sequential order from 1 - 32 with t-scores in parentheses ($P \leq .1$, one-tail)

*** Critical elements listed in PAQ sequential order from 1 - 194, average mean in parentheses (Critical rating = 2.5 and above)

# APPENDIX F

## Significant Attributes and Attribute Dimensions of a Generic Tactical Command and Control Workstation Using the 52 Critical Elements in Appendix F

1. Cognitive Skills Dimensions*

| | | |
|---|---|---|
| 7. | Divergent thinking** | (4.73) |
| 14. | Closure | (4.62) |
| 6. | Convergent thinking | (4.17) |
| 8. | Intelligence | (3.49) |
| 9. | Long-term memory | (3.31) |
| 10. | Short-term memory | (3.23) |
| 5. | Arithmetic reasoning | (3.09) |

2. Visual Perception/Interpretation Dimension

| | | |
|---|---|---|
| 14. | Closure | (4.62) |
| 13. | Perceptual speed | (3.44) |
| 12. | Visual form perception | (2.70) |

3. Quantitative Skills

| | | |
|---|---|---|
| 4. | Numerical computation | (3.98) |
| 5. | Arithmetic reasoning | (3.09) |

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* Attribute dimensions listed in order of importance

** Significant attributes listed in sequential order from 1 - 49 with t-scores in parentheses ($P \leq .005$, one-tail)


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